Investigation of heat induced deformation of metallic profiles by a laser welding process

Experimentally validated FEM model for preheating, laser welding and cooling

Graduate

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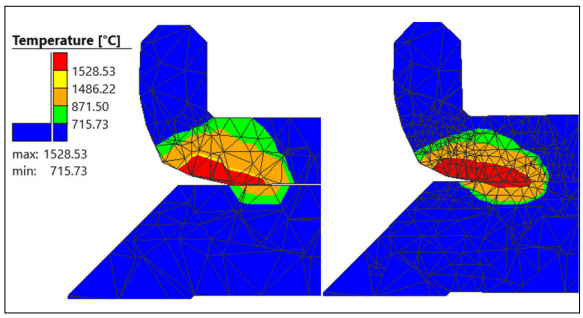
Introduction: In this work, a laser welding joining process of thermally insulating profiles is studied. These thermally insulating profiles are made up of long, hollow metallic tubes connected in between with a metallic thermal break structure that has to be joined by laser welding. Depending on the choice of process parameters during the welding process, the accompanying heat distribution generated in the process will cause a remaining deformation on the cooled profile. An optimum production process should minimize this deformation by setting optimum process parameters such as preheating power, duration, laser power, power distribution, welding sequence, welding speed and cooling.

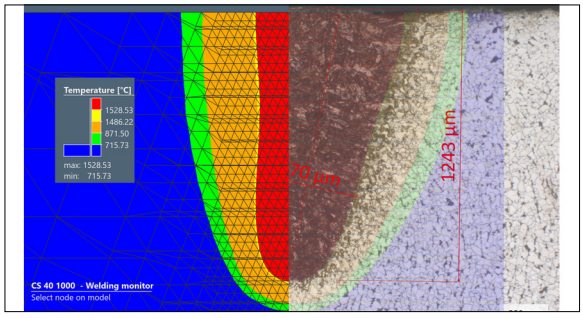
Definition of Task: The aim of this work is to investigate the applicability of the Finite Element Method (FEM) for simulating the laser welding process and other accompanying processes such as pre-heating and cooling of these thermally insulating profiles. To this end, the existing welding process of the manufacturer is realized in a coupled thermo-mechanical FEM simulation and validated based on measurements performed in an extensive design of experiments (DOE) study. The validated model serves as the basis for a parameter study in order to investigate the influence of various process variables on deflection.

Result: This thesis demonstrates that laser heat input power and distribution can be accurately mapped in a FEM simulation model. The simulated heat-affected zones, weld shape, and weld depth correspond well with those measured in metallographic cross-sectional examinations. However, the deformation can only be predicted qualitatively in the simulation, which means that no quantitative statements can be made about the influence of preheating, laser power, material, and geometry. The differences between the measured and simulated curvature are primarily due to edge effects and high numerical sensitivity resulting from the necessary geometric shortening and simplification of the simulation model due to extended simulation times.

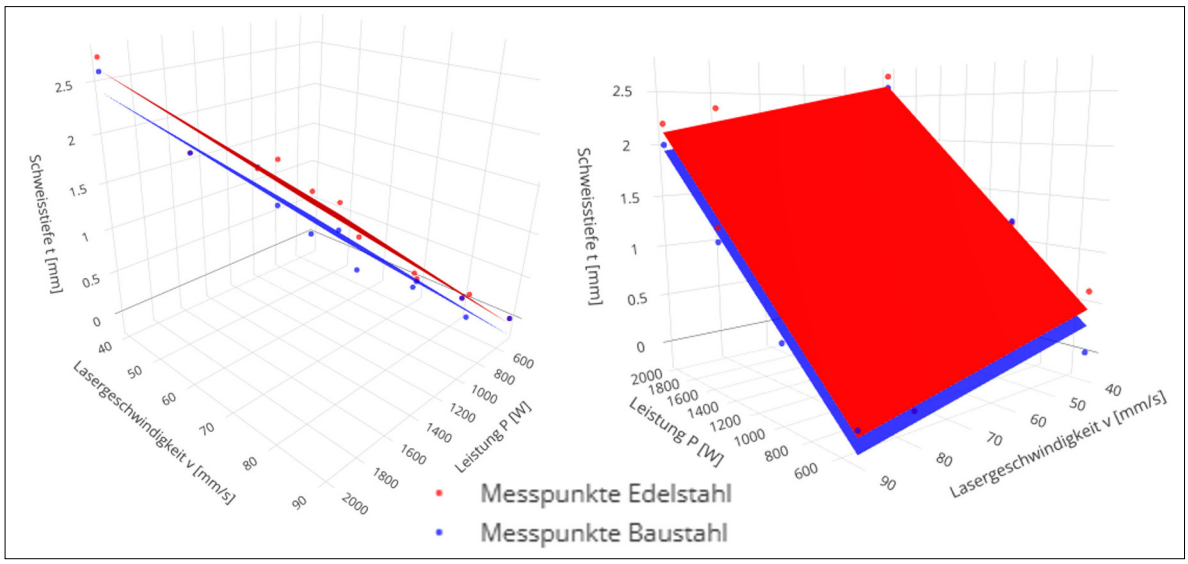
Optimisation of profile meshing: Local refinement for precise FEM mapping of weld seam geometry.
Own presentment



Validation: Comparison of the simulated weld seam with the actual metallographic analysis of the fusion zone.
Own presentment



Prediction of weld depth using a linear regression model based on laser power P and laser velocity v.
Own presentment



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Subject Area
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